Spectroscopic Study of the High-latitude far Evolved Star V534 Lyr

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Abstract. We study a pulsating variable post-AGB star V534 Lyr = HD172324 based on five high resolution spectra (R = 60 000) obtained with the NES echelle spectrograph of the 6–meter Russian telescope (BTA) in 2010 and 2013. Using the atmosphere modeling method and the Kurucz model set, we obtained the effective temperature $T_{\rm eff}$ = 10500 K, surface gravity $\log g = 2.5$, and microturbulent velocity ξ_t=4.0 km/s. The underabundance of the iron group elements $[{\rm Met/H}]_\odot = -0.50$ was detected. This fact in combination with high spatial velocity indicates that V534 Lyr does not belong to the disk population. The radial velocity gradient in the V534 Lyr atmosphere is minimum: differential shifts of lines are close to measurement errors The spectral class A0 Iab corresponds to the distance to V534 Lyr, d≈6 kpc.

1. Introduction

Over the two past decades AGB and post-AGB supergiants and several luminous stars with unclear evolutionary status have been spectroscopically monitored with the 6-m telescope of the Special Astrophysical Observatory (author of the program – V.G. Klochkova). Main results of this long-term study are presented by Klochkova (2014); Klochkova & Panchuk (2016).

In the present paper we consider some details of the optical spectra of one of the objects of this program – far evolved star V534 Lyr = HD 172324. V534 Lyr is a pulsating variable post-AGB star with the galactic coordinates: l = 66.2°, b = 18.6°. Its spectral class A0 Iab was determined by Bonsack & Greenstein (1956), physical properties and chemical composition of the atmosphere are studied by Giridhar & Allende Ferro (2005).

This work is based on five high resolution spectra (R = 60 000) obtained with the NES echelle spectrograph (Panchuk et al 2009) of the 6-m Russian telescope (BTA) in 2010 and 2013. Extraction of one-dimensional spectra from two-dimensional echelle images was conducted with the modified variant by Yushkin & Klochkova (2005) of the ECHELLE context of the MIDAS package. Wavelength calibration was carried out from the spectra of a Th–Ar hollow-cathode lamp. One-dimensional spectra were reduced in the DECH20t code (Galazut-

dinov 1992). Radial velocities were measured through fitting of the direct and mirror images of line profiles. The fitting of spectra of the star and the lamp was checked using the [OI], O_2, and H_2O telluric lines. The root-mean-square error of the radial velocity Vr for narrow absorptions is 1.0 km/s at most.

2. Main results

The table shows the data on the spectra and average heliocentric velocities Vr for several groups of lines. Columns 3–6 contain the averaged Vr for:

- FeII 6318, 6384, and 6385 Å emissions,
- HeI and S II absorption core,
- components' core of the FeII absorptions of high excitation (potentials of lower levels are equal to about 10 eV),
- components' core of the FeII absorptions of low excitation (potentials of lower levels are equal to ≈1 eV) respectively.

Table 1. The data on the spectra and average heliocentric velocities Vr in km/s for several groups of lines.

Date	$\Delta\lambda$	Vr(emiss)	Vr(absorptions)		
	nm	FeII	HeI, SII	FeII high	FeII low
06.04.10	516-669	−131	−131	−132	−103
					−152
01.06.10	522-669	−123	−120	−120	−107
					−156
30.07.10	443-593		−124	−125	−125
24.09.10	522-669	−127	−130	−130	−128
12.10.13	392-698	−114	−120	−108	−109
					−146

The figure presents the dependences between the radial velocity Vr and the central residual intensity (r). Each line corresponds to one or two signs (in cases of bifuricated absorptions). As distinct from other super and hypergiants, for this star they are not stationary and show velocities close to those for unsplit absorptions.

The table and figure obviously show the position variations of all the lines and shapes of profiles of some of them with time. This primarily refers to the splitting of FeII absorptions of low excitation forming in the upper atmospheric layers; the absorptions of high excitation forming deeper stay single.

The radial velocity gradient in the V534 Lyr atmosphere is minimum, 30.07.10 and 24.09.10: differential shifts of lines are close to measurement errors. On that

basis, one can suppose that center-of-mass velocity of the star, Vsys, is close to -125 km/s ($V_{lsr} \approx -105$ km/s).

The spectral class A0 Iab corresponds to the distance to V534 Lyr, d$\approx$ 6 kpc. Interstellar line profiles of NaI (1) and CaII (1) are also indicative of great distance: the presence of the components with Vr $=-46$ km/s in them indicates d$>$ 7 kpc as in (Brand & Blitz 1993). Notable proper motion (3.6 ± 0.8 mas) at d$\approx$ 6 kpc is corresponding to 103 km/s; the star is near to the Galactic plane. In combination with $V_{lsr} \approx -105$ km/s, it yields a spatial velocity of about 140 km/s.

Using the model atmospheres method and the models set by Kurucz (1993), we obtained the effective temperature $T_{eff} = 10500$ K, surface gravity $\log g = 2.5$, and microturbulent velocity $\xi_t = 4.0$ km/s. The underabundance of the iron group elements $[Met/H]_\odot = -0.50$ was also calculated with this atmospheric model. This fact as well as high spatial velocity indicates that V534 Lyr does not belong to the disk population.

Among stars we studied earlier, the anomalous supergiant UU Her, the prototype of the class of variable supergiants located at high galactic latitudes may be considered as a nearest analogy of V534 Lyr. Based on several high-resolution spectroscopy of the star over 5 years with the 6–m telescope, Klochkova et al. (1997) found a low metallcity $[Fe/H]_\odot = -1.32$ and the large radial velocity $V_r \approx 130$ km/s. In whole obtained results led these authors to conclude that UU Her is a low-mass star beyond Galactic disk.

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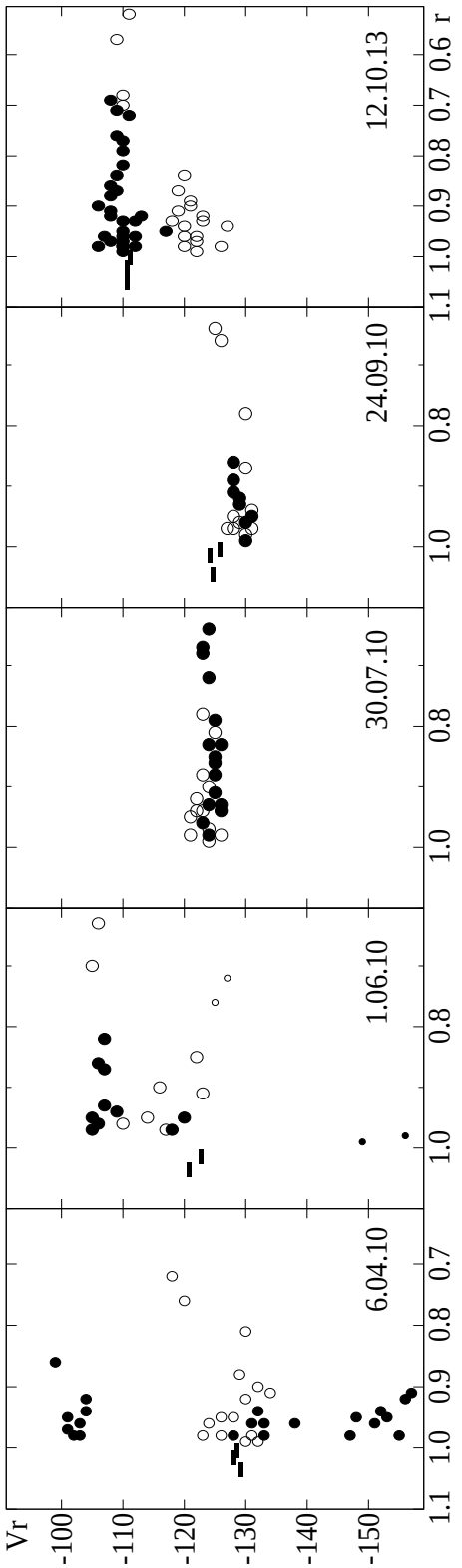

Figure 1. Relation between the radial velocity Vr and the central residual intensity (r). The filled circles refer to FeII, the open ones – to HeI, SII, and SiII (2), horizontal little lines – to emissions.